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BUILDING NEW ROAD CAPACITY

An urban area's transportation system consists of a network of highways and streets, transit services, nonmotorized modes of transportation, and access linkages to intermodal terminals.

On a daily basis, this system handles large volumes of passengers and freight, and over time is directly related to the health of an urban economy and to urban development patterns. Adding new capacity to the highway system to "solve" transportation problems has been the most common approach adopted by state and community officials. As noted in Chapter 2, improved system management techniques can provide greater throughput by more efficiently using existing capacity. In this chapter, capacity expansion will be viewed from the perspective of adding new infrastructure to the transportation system. Such action can be undertaken for many reasons. Mobility and accessibility in an urban area has traditionally been provided by the physical movement of people and goods (however, with the advent of modern telecommunications technologies, some of this movement might no longer be necessary; see Chapter 5). New highway capacity is thus considered as a means of relieving already congested streets by providing more capacity to handle those demands. New highway capacity can enhance traveler safety by improving hazardous locations. And more broadly new transportation capacity can be used to provide improved access to specific sites or corridors in a region (e.g., see joint development discussion in Chapter 4).

One of the major differences with actions discussed in this chapter compared with those in other chapters is that, in almost all cases, actions to add capacity are subject to planning and environmental requirements that must be followed to secure financial support. For example, new highway and transit facilities that have regional significance must be part of a comprehensive transportation planning process that considers a variety of alternative transportation modes in meeting community goals and objectives. One of the results of this planning process is the identification of areas where transportation services are currently deficient or likely to be deficient in future years. Different alternatives for meeting these objectives are then examined in the planning process.

New highway and transit facilities that have regional significance must be part of a comprehensive transportation planning process that considers a variety of alternative transportation modes in meeting community goals and objectives.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 also required that a major investment study (MIS) be undertaken where a major transportation investment is identified through the planning process as satisfying a need, and where federal funds are potentially involved. A major investment includes "high-type highway or transit improvements of substantial costs that are expected to have a significant effect on capacity, traffic, level of service or mode share at the transportation corridor or sub-area scale"(U.S. DOT 1995). If the proposed project is expected to have significant environmental impacts, an environmental impact statement (EIS) or environmental assessment (EA) will have to be undertaken. The draft EIS can be done in conjunction with the MIS. In addition, if the urban area is in non-conformance with air quality standards, a conformity analysis must be undertaken which shows no additional degradation of air quality due to the proposed project.

The planning process that precedes project implementation should take a careful and comprehensive look at all of the consequences of adding capacity to the transportation system.

As part of all these efforts a proactive public involvement process is necessary to provide opportunities for public input and participation. These efforts are not only desirable, but required under ISTEA, and other related federal laws such as the Clean Air Act and the Americans With Disabilities Act (U.S. DOT 1994).

A final consideration with the types of actions described in this chapter is the timeframe of benefits and costs associated with each project. Because many of these actions are undertaken at a large scale and result in significant improvements in mobility and accessibility, the timeframe for benefits and costs tends to be long term in nature (see Chapter 1). The benefits of transit or highway expansion might not occur for many years as land use and travel behavior slowly responds to the new mobility or accessibility that it represents. Similarly, societal costs associated with capacity expansion in terms of new travel demand that is generated (called induced demand) and the consequent impacts on land use and on the environment will also likely occur over a longer time frame. Therefore, the planning process that precedes project implementation should take a careful and comprehensive look at all of the consequences of adding capacity to the transportation system.

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Multimodal Transportation Corridor Investment

Description: One of the new approaches to multimodal capacity expansion (and one that is encouraged by ISTEA) is expanding the transportation capacity in a travel corridor where capacity is defined in terms of total number of persons or goods that can be accommodated on corridor facilities over a given period of time. (The Urban Institute 1993). This definition of corridor capacity implies that it does not matter which mode of transportation provides this mobility, simply that one or a combination of modes provides the maximum throughput of persons and goods given the limitation in the amount of investment dollars that are available. This approach is said to be multimodal, which implies that, "1) the problem is defined in a generic way (that is, in a non-mode-specific manner), 2) more than one modal option to solve this problem is identified; and 3) the modal options are evaluated in a manner that provides for an unbiased estimation of each mode's contribution, either individually or in combination, to addressing the problem" (Meyer 1993).

This approach is relatively new in the transportation profession. A study of multimodal project evaluation found that few studies examined a wide range of different modal alternatives, and importantly that few studies used mobility-oriented evaluation criteria in the project planning process (Rutherford 1994). Florida, one of the first states to formally propose multimodal transportation corridor design, has adopted a scheme whereby the ultimate design of facilities in urbanized areas over 200,000 population will include up to four HOV exclusive lanes (see Figure 3 -1). No more than six lanes will be provided for general traffic use. Note in Figure 3-1 that provision for non-motorized transportation modes is not provided although in some cases such capacity should be seriously considered. Any expected demand over what is satisfied by this freeway design will be handled with alternative transportation options, i.e., transportation demand management and fixed guideway transit (Florida DOT 1996). Figure 3-2 shows an urban application of a multimodal transportation corridor.

Multimodal corridor capacity expansion implies

- *that the problem is defined in a non-mode specific manner*
- *more than one modal option to solve the problem is identified*
- *modal options are evaluated in a manner that provides for an unbiased estimation of each mode's contribution*

Benefits/Costs: Investment in multimodal transportation corridors is a relatively new concept, therefore there is little evidence of the benefits and costs associated with such an approach. In fact, as a first approximation, the benefits and costs of a multimodal project can be viewed from the perspective of the benefits and costs of individual modal projects combined into one corridor project. One of the few examples in the United States of examining a wide range of multimodal options in a transportation corridor occurred in Salt Lake City, Utah during an analysis of alternative transportation improvements in the I-15 corridor (Wasatch Front Regional Council

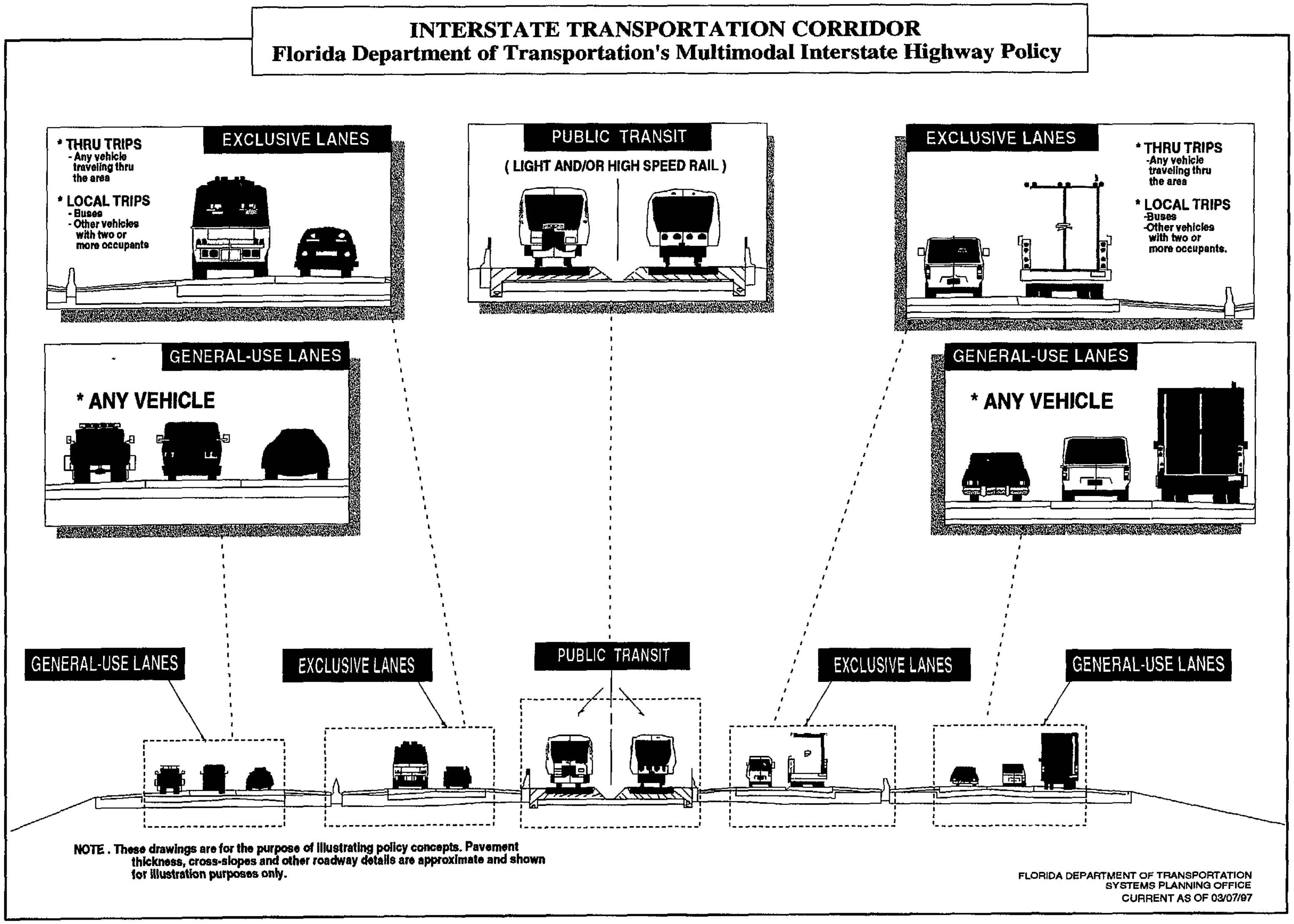
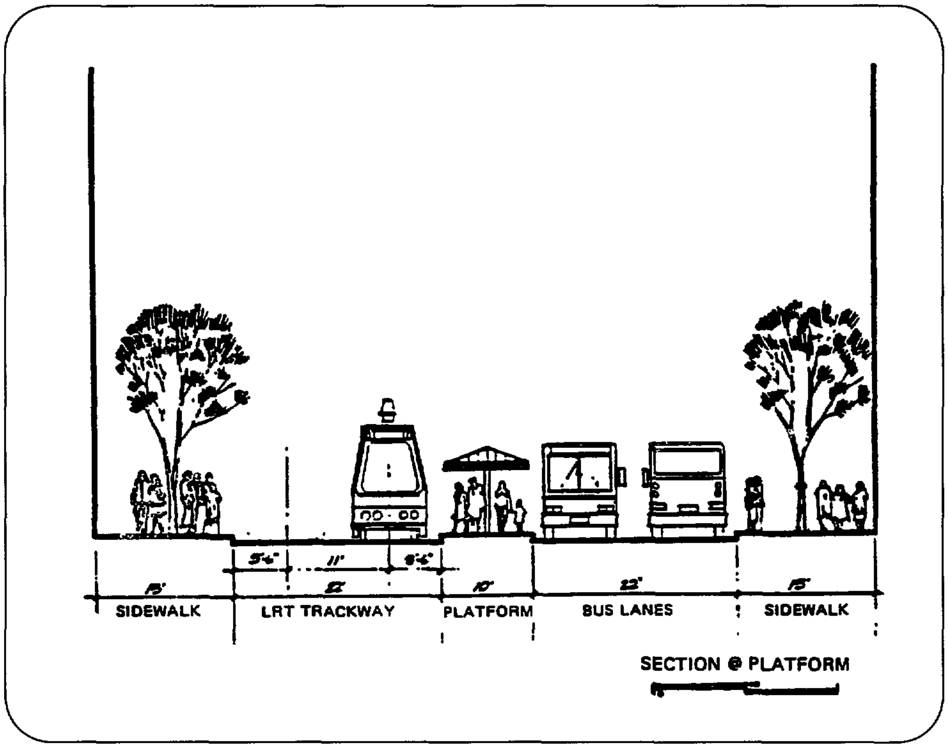


Figure 3.1: Florida's Multimodal Highway Design Concept

Source: Florida DOT 1996

Figure 3.2: Urban Multimodal Transportation Corridor



1991). Many different alternatives were considered for this corridor including:

- ➤ No Build
- ➤ Best Bus
- ➤ Best Bus + One Highway Lane
- ➤ Best Bus + Two Highway Lanes
- ➤ Reversible HOV Lanes
- ➤ Two-way HOV Lanes
- ➤ Light Rail Transit (Two Alignments)
- ➤ Light Rail Transit (Four Alignments) + One Highway Lane
- ➤ Light Rail Transit (Two Alignments) + Two Highway Lanes

Each of these alternatives had different savings in person hours of travel for those using the freeway, the proposed HOV lanes, and the proposed light rail facility. As one would expect, the costs associated with each alternative also varied substantially given the different infrastructure requirements for different modal options.

The benefits of multimodal transportation investment are primarily related to the increased mobility and accessibility provided by the new transportation capability. This could mean improvements in travel time, safety, economic development, environmental quality, community quality of life and reduced congestion in the transportation corridor.

Implementation: Multimodal project planning requires a non-traditional perspective on transportation improvements. Effective multimodal planning first begins with the establishment of partnerships between agencies responsible for a facility (e.g., a state department of transportation) and other concerned groups and organizations (e.g., a metropolitan planning organization), the development of multimodal advocacy groups within these partnerships, and establishing a financing base that per-

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TDM Measures Considered in U.S. 301 Corridor Investment Planning

Voluntary Measures

- Transportation Management Association in Major Employment Centers
- Employee Vanpool Program
- Home-based Ridesharing Program
- Local Area Paratransit Program with Community Centers
- Improved Park-and-Rrde Amenities
- New Park-and-Ride Lots
- Additional Area Telework Centers
- Additional Bike/Pedestrian Facilities in Study Area
- Transit-Onented Development Amenities
- TDM in the Development Approval Process

Pricing Measures

- Congestion Pricing/Reduced Transit Fares
- Parking Pricing for Public Facilities
- Parking Cash Out

mits a mix of funding sources for multimodal projects (Transmanagement, Inc. 1996).

Given the multimodal nature of project alternatives, the implementation of this action requires widespread and active participation of a variety of groups and organizations. This could include both private and public transit service providers, employers and developers, community officials, environmental groups, government agencies, business associations, local public groups, and other interests that would be concerned about the impacts of such investment. A good example of such an approach is the U.S. 301 Task Force established by the Maryland Department of Transportation (Carlson 1995). This Task Force consisted of over 50 groups with a vested interest in the U.S. 301 corridor, including the Audubon Society, National Resources Defense Council, Sierra Club, local governments, and advocates for growth management, conservation, and the construction industry. Although this process took many years to complete, the inclusion of all these groups provided for a consensus improvement plan that included both transit and highway actions.

Project planning and development for a multimodal corridor investment project would most likely occur within the context of an MIS/EIS effort, and thus public participation would be present throughout the planning and project development phases. The implementation of a project such as this needs to consider the following: ultimate goals and objectives for the communities in the corridor and for the region, desirable transportation system performance, analysis tools that can handle multimodal tradeoff analysis and evaluation, financial limitations, and the long- and short-term implications of improvements to the transportation system. In most cases, the capital investment in transportation infrastructure must be considered in the context of a broader transportation and land use program of actions that, in combination, can provide the desired mobility and accessibility. For example, the transportation demand management (TDM) options located in the first column of this page were considered as part of the U.S. 301 project discussed above (see Chapter 5 for a more detailed description of TDM). As can be seen, this list goes way beyond simple design concepts for highway alignment.

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New Highways

Description: The construction of highways on new rights-of-way is being considered in many urban areas as an important means of reducing urban traffic congestion and enhancing the mobility of those who primarily rely on the automobile for transportation. Such construction, as defined here, means building a new highway where one currently does not exist. Most often these highways are new expressways designed to relieve traffic congestion on nearby roads, improve safety in a corridor, provide access to industrial/commercial/residential land, or some combination of the above. The requirements for such an action include purchase of new right-of-way, mitigation of negative impacts on the natural environment and on residents/businesses, and the application of typical design standards that guide the final design of the project.

In urban areas, design standards can often be contested by local residents who desire something other than what is being proposed. For example, the Presidential Parkway in Atlanta had been proposed by the state department of transportation to be a typical four 12-foot/3.6 meter lane expressway running through some of the oldest neighborhoods in Atlanta (Carlson 1995). After 15 years of protest, and $900,000 in litigation, a compromise was finally accepted which resulted in a two-lane, at-grade, meandering parkway with very low speed limits. The project scope had been redefined so that different design standards became relevant to the project.

The construction of highways on new rights-of-way means building a new highway where one currently does not exist. Most often these highways are new expressways designed to relieve traffic congestion on **nearby** *roads, improve safety in a corridor; provide* access *to industrial/commerciailresiden tial land, or some combination of the above.*

Benefits/Costs: By diverting vehicles that currently use the existing road system, a new highway can in the short-term reduce congestion on arterials and local streets in the corridor. The magnitude of this impact depends on how easily the new road can be reached and its ability to serve the employment and shopping sites to which the vehicles are destined. Over many years, however, the new road itself can attract new development, and unless otherwise guarded against by controlling access or through growth management, the road could simply become another source of congestion and resultant environmental impacts. Depending on the circumstances, other benefits of new highways could include a decrease in accidents (by diverting traffic from poor roads), an increase in local tax base (by attracting development and jobs), and the diversion of through traffic or trucks from local streets.

The costs of highway construction vary from one part of the country to another. The project cost can depend on the cost of purchasing right-of-way, the type of construction materials to be used, the design of the road, whether bridges are part of the design, and a multitude of other factors. The typical costs associated with highway and transit improvements are shown below [note that different regions will have different cost structures and cost escalators, and that construction costs will very much depend on alignment and technology considerations (Henk, Poe, and Lomax 1991)].

Construction of:

➤ Principal arterials
$1.5 million/lane-mile
($0.94 million/lane-km)

➤ Super arterials
$3-4 million/lane-mile
($1.7-2.5 million/lane-km)

➤ Freeways
$4-5 million/lane-mile
($2.5-3.1 million/lane-km)

➤ Toll roads
High

➤ HOV facilities
- Barrier separated
$4-10 million/lane-mile
($2.5-6.2 million/lane-km)
- Concurrent/contra
$0.5-2 million/lane-mile
($0.3-1.2 million/lane-km)
- Arterial HOV lanes
$0.5-2 million/lane-mile
($0.3-1.2 million/lane-km)

➤ Commuter rail
$5-10 million/mile
($3.1-6.2 million/lane-km)

➤ Light rail transit
$20-30 million/mile
($12.4-18.6 million/lane-km)

➤ Heavy rail transit
$80-100 million/mile
($49.6-62 million/lane-km)

Addition of:

➤ Principal arterial lane
$0.5-1 million/lane-mile
($0.3-0.6 million/lane-km)

➤ Freeway lane
$2-4 million/lane-mile
($1.2-2.5 million/lane-km)

Reducing Lane Width or Using Shoulder:

$0.5 million/lane-mile
($0.3 million/lane-km)

Grade Separated Arterial Intersections:

$5-6 million/intersection

There are other longer term societal costs of highway construction that often do not surface until many years later. Because a new highway will likely influence where new development occurs, the highway can have a redistributional impact on development at the regional level, encouraging development to occur along the highway at the expense of other parts of the region. In addition, because the new highway makes it easier to travel via the automobile, it could negatively impact an urban area's policy of encouraging non automobile transportation. Therefore, the evaluation of highway construct-tion projects should carefully consider not only the primary benefits and costs to the traveling public, but also the secondary and tertiary impacts (e.g., needs for public services in newly developed areas) that will occur due to changing development patterns that are responding to a major enhancement in accessibility.

Implementation: The most difficult aspect of building new urban highways is often achieving a consensus that such construction is the appropriate course of action. (In some areas of the country, voters have approved the construction of new highways (e.g., Phoenix, Atlanta, and Houston) by voting to approve transportation bonds that support highway construction. In others, such construction has been opposed by groups who feel that new highways are not in the best interest of the community. In most cases, proposals for new highways need to be carefully prepared so that their benefits and impacts can be truly understood, and the ultimate decision should reflect not only the short-term consequences of a new highway, but also the long-term impacts.

In most cases, highway project development will follow standard procedures established by the "owning" agency for the project development process. This process should include proactive public involvement and a consideration of a wide range of alternatives (see discussion above on multimodal transportation corridors). In addition, transportation demand management options should be considered in the context of a strategic effort to better manage transportation demand in the corridor.

Another important aspect of implementation is the corresponding design requirements associated with different funding sources. Typically, federal or state-funded projects are on facilities that carry higher volumes of traffic at higher speeds, and are therefore designed to higher safety Stan dards [see, for example, AASHTO 1997)]. Thus, the cost per mile will be higher than that for a local road that typically carries lower volumes at lower speeds. Design standards therefore are directly related to the functional classification of the road (local, collector/distributor, arterial, major arterial freeway, etc.) and the character of traffic expected to be on it so that the users are provided with a safe roadway section based on how they intend to use it.

The most difficult aspect of building new urban highways is often achieving a consensus that such construction is the appropriate course of action Proposals for new highways need to be carefully prepared so that their benefits and impacts can be truly understood, and the ultimate decision should reflect not only the short-term consequences of a new highway, but also the long-term impacts.

Highway finance is another important consideration in the construction of new highways. If tolls are to be used to repay bonds that were sold to construct the highway, the projected toll revenue amount and timing will likely influence the scheduling of highway construction. If other forms of innovative financing are to be used, (e.g., developer contributions), negotiations must assure that the amount and timing of such finance is appropriate and adequate to fund the highway project. ISTEA requires transportation plans and programs to be financially constrained which means that funding sources for all major transportation projects must be identified and committed.

(Additional material on highway finance is presented in Chapter 7 of the Toolbox.)

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Access control and management refers to the implementation and enforcement of guidelines that determine the manner in which users will be provided access to a highway facility

Access Control and Management

Description: Access control is one of the most significant factors in the safe, efficient operation of a highway. Highways are classified according to the function they are expected to serve in the road network (this is referred to as a functional classification). The functional classification of highways is in part based on the concepts of accessibility (access to abutting property) and mobility (ability to travel). Access control and management refers to the implementation and enforcement of guidelines that determine the manner in which users will be provided access to a highway facility. Local streets whose function is primarily to serve abutting land uses are designed for accessibility. Freeways and expressways are designed primarily to provide mobility and do so by allowing vehicles on the road only at selected points.

Benefits/Costs: The benefits and cost considerations for access control and management are discussed in Chapter 2 and thus are not repeated here.

Implementation: The implementations considerations for access control and management are discussed in Chapter 2 and thus are not repeated here.

Geometric Design

Description: The geometric design of a highway consists of all the physical characteristics of the highway that must be considered in the design process. These include horizontal and vertical alignment, clearance, number and width of lanes, shoulders, medians, traffic control devices, bridges, and right-of-way. The engineer uses design criteria that reflect such factors as design traffic volume, design speed, and sight distance. In most situations, there is not one "perfect design solution." Instead, there are often a number of feasible solutions.

Benefits/Costs: Proper implementation of geometric design standards could result in one or more of the following benefits:

Increased Traffic Flow: For example, increasing the distance to obstructions on both sides of a freeway having two 12 footl3.6 meter lanes (in each direction) from 1 foot/O.3 meter to 6 feet/l.8 meter could increase the volume to capacity ratio (one measure of facility performance) by about 10 percent (Transportation Research Board 1985). Other options include straightening alignments to remove low speed or high accident locations, increasing lane width, and providing climbing lanes for slower vehicles.

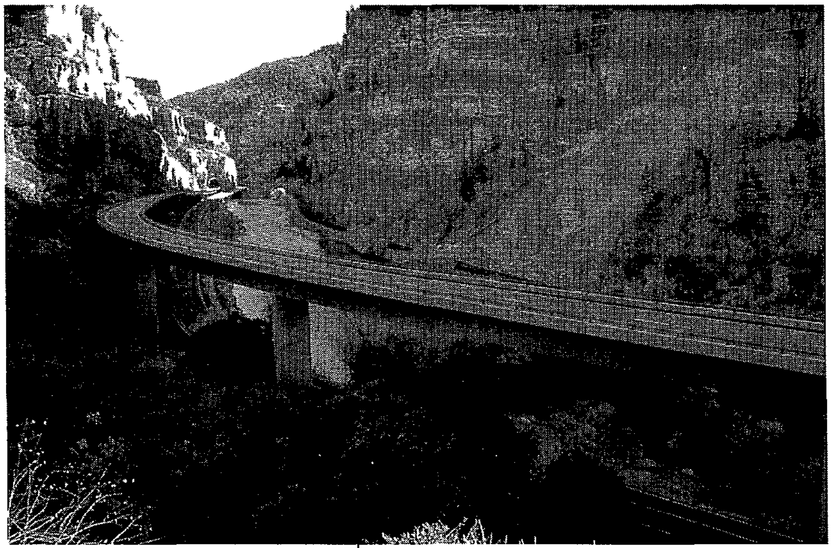
Improved Safety: For example, in certain cases, an improperly aligned highway with sharp curves may have five times as many accidents compared to a highway with good align ment and long straight stretches of road. The design elements that can influence safety include: (McGee,

Category	Design Element
Honzontal Alrgnment	Degree of curvature Superelevation
Vertical Alignment	Grade Critical length of grade Vertical curves sag and crest
Cross Section	Number of lanes Lane width Shoulder type Shoulder width Median type Median width
Roadside	Sideslopes Honzontal clearance to obstructions ditch design Traffic barriers roadside Median barriers

Hughes, and Daily 1995).

As noted in a recent review of highway design standards and safety implications, 12-foot/3.6 meter lanes are "safe", 11 -foot/33 meter lanes are "safe enough" for urban situations, and 10- and 9-foot/3.0 meter and 2.7 meter lanes will "work" under conditions of low speed, low volumes, and few wide vehicles (McGee, Hughes, and Daily 1995).

Reduced Construction and Right-of-Way Costs: For example, one possible design of an elevated interchange between two intersecting expressways could be a 500-foot/152 meter radius ramp and a design speed of 55 mph/88 kph. Applying geometric design principles, it can be shown that the two expressways can also be connected by a ramp with a radius of 150 feet/46 meter and a design speed of 30 mph/48 kph (AASHTO 1994). The construction costs for the second ramp would be about 30 percent of the cost



Interstate 70, *Glenwood Canyon* Colorado

of the fiit ramp, while the right-of-way cost for the second ramp could be a low as 10 percent of the cost of the first ramp.

Better Aesthetics: Enhanced aesthetics of the highway can be planned and built into the design phase of any project. The design and construction of Interstate Highway 70 through the picturesque Glenwood Canyon in Colorado is testimony to the benefits and importance of aesthetics (Proscence and Haley 1980). Bridges can also serve as an intrusive element into the natural surroundings. By considering different shapes of the superstructure, piers, horizontal alignment, material texture, and protective fencing/ screening, engineers can make such structures better fit with their surroundings (Bacow and Kruckemeyer 1986).

As was the case with new highway construction, any improvements that result in increased traffic flow should be evaluated from the perspective of their long-term impacts on urban form and on the environment.

Implementation: The proper implementation of most aspects of geometric design can be achieved by adhering to design principles and policies found in a variety of design manuals. Importantly, the designer must be aware of the relative costs of various levels of design standards versus the present and long-range benefits of the design features that are associated with these standards. As noted in (AASHTO 1994; 1997), however, the designer often has some leeway in applying design standards. Sufficient flexibility should be provided to encourage independent designs tailored to particular situations. In addition, "joint use of transportation corridors by pedestrians, cyclists, and public transit vehicles has been emphasized" so that people movement, distribution of goods and provision of essential services is considered as well as the benefits to highway users.

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Reconstruction and Traffic Management

Description: Highway reconstruction is the process of replacing or rehabilitating a road. Reconstruction projects include modernizing geometric and structural standards, improving the quality of operation and safety, increasing capacity, and extending the life of facilities. The elements required for reconstruction projects are basically the same as for new construction, but additional tasks are required for planning and coordinating construction sequences and developing detailed plans that will minimize the disruption to the traveling public.

Importantly, the reconstruction of a facility provides an opportunity to correct or improve operational problems that developed since the facility was built. These improvements could include: access/driveway restrictions and other changes in access control, turn lanes, advanced traffic signal control, compact interchanges to eliminate intersections, improved interchange design, conduit and cabling for surveillance and communication systems ramp metering, or at the very least providing in the design the ability to implement such things at a later date.

Benefits/Costs: The benefits associated with highway reconstruction are primarily related to increased safety and possible improved access control that will occur after the reconstruction project. The reconstruction of existing roads usually occurs in areas where the surrounding land uses have already been developed to near their market potential, whereas new highways primarily provide new accessibility to developable land. Therefore, new highways will likely have a big ger impact on development patterns than the reconstruction of existing roads.

A major issue with highway reconstruction is maintaining traffic flow and access to surrounding land uses during the reconstruction period. The principal challenge of traffic management during reconstruction, therefore, is minimizing traffic disruption. The reconstruction project for the

Highway reconstruction is the process of replacing or rehabilitating a road. Reconstruction projects include modernizing geometric and structural standards, improving the quality of operation and safety increasing **capacity** *and extending the life of facilities.*

Woodrow Wilson bridge (I-95) in Washington, D.C., is a good example of how innovative construction techniques and scheduling minimized traffic disruption. The entire redecking of the bridge was accomplished by using prefabricated slabs lifted into place by a barge moored underneath the bridge. The innovative efforts of the contractor allowed all three lanes to be operational during peak period hours.

The Boston Southeast Expressway is another example of how traffic management techniques were used to minimize traffic congestion during reconstruction. Techniques included the creation of two contraflow lanes during peak periods, additional park-and-ride lot capacity, an information brokerage program, identifying ridesharing options, signal and pavement marking improvements on alternate routes, expanded mass transit capacity, sponsoring a conference to encourage employers to implement variable work hours, directed police enforcement, financial assistance to local communities for traffic mitigation activities, and a public information campaign. Overall, the efforts resulted in a 9 percent decrease in northbound traffic and a 3 percent decrease in southbound traffic. Average travel time was reduced by three to four minutes on this 10-mile/16.1 -km expressway (Meyer 1985).

A Baltimore highway reconstruction project has also used traffic management techniques to accommodate 95,000 vehicles a day on the expressway. The number of expressway lanes was reduced from three to two during peak periods. An elaborate alternate route system was developed providing 15 options to arrive in the downtown area. The state highway agency spent nearly $10 million to improve the alternate route facilities. Additionally, $1.2 million was spent on a public relations campaign to inform motorists about the reconstruction project and alternate routes. As a result of these efforts, the expressway handled per day between 20,000 to 25,000 fewer vehicles (Janson, et al 1987).

Implementation: Successful implementation of reconstruction projects must be done with minimal traffic disruption and generally within existing right-of-way. Construction sequences must be carefully planned and coordinated and planners must be careful to incorporate features that maximize system-wide mobility.

For the final design (i.e., after reconstruction), three important principles are usually followed for freeways: interchange uniformity, lane balance, and route continuity. Interchange uniformity requires that interchanges along a freeway system assume a consistent operational pattern, i.e., a similar arrangement of exits and entrances at interchanges along the freeway. Lane balance incorporates the basic number of lanes for exiting and entering traffic. The basic principle requires that for exits the number of lanes on the freeway and ramp after the exit should be one more than on the freeway preceding the exit, and for entrances the number of lanes prior to the merge should equal or be one less than after the merge. Route continuity requires direct and natural paths for motorists through interchanges in order to reduce driver confusion.

For traffic management during reconstruction, successful implementation requires effective and thorough planning and public education. Criteria that can be used to assess the potential effectiveness of individual strategies include:

- Does the strategy provide added opportunity for highway users to use alternative modes or routes?
- Can the strategy be implemented in time?
- Will the strategy be cost effective in terms of dollars spent per level of disruption reduction?
- Will the strategy contribute to permanent transportation improvements after the reconstruction project is finished?
- Can the strategy be terminated if found to be ineffective?

The Edens Express Project (I-94) in Chicago and the Parkway East (I-376) project in Pittsburgh document the advantages of effective planning. In Pittsburgh, plans were developed to evaluate the effectiveness of the strategies implemented in the first year, and provided for second-year implementation of more cost-effective procedures (Anderson and Hendrickson 1983). Without adequate planning, it would have been difficult to identify and implement the modifications in a timely manner.

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By removing conflicting traffic flows from the intersection, grade separation is an effective method for increasing the capacity of an intersection.

Grade Separation

Description: Grade separation is the separation by physical means (e.g., an overpass) of different flows of traffic. Grade separation of vehicles and pedestrians can also be used to reduce congestion and to increase pedestrian safety in urban areas with high concentrations of pedestrian activity. A railroad grade separation is the result of using a grade separation to vertically separate the intersecting highway and railroad. In terms of safety and operating efficiency, a railroad grade separation is the optimum improvement to an at-grade crossing for both the highway user and the railroad.

Benefits/Costs: Inadequate road capacity is the primary cause of congestion in and near intersections. Because two crossing roadways must share a common crossing area (i.e. the intersection), a scheme must be developed to apportion the usage of the intersection to each of the crossing roadways. By removing conflicting traffic flows from the intersection, grade separation is an effective method for increasing the capacity of an intersection.

Although grade separation is always beneficial in terms of adding capacity to a congested intersection, the means of doing so (that is, the construction of overpasses), may be costly due to the high cost of construction, right-of-way requirements, and the disruption of traffic and businesses during construction. An alternative to the conventional grade sep aration structure is a "flyover." These structures can be constructed with minimal disruption to traffic and generally within a fully developed lOO-foot/30 meters right-of-way. Three flyovers constructed in Chicago during the late 1950's and early 1960 illustrate the benefits that can be realized from the construction of these grade separation structures:

- Capacity of the three intersections increased an average of 114 to 300 percent.
- Peak hour flows at nine of the intersection approaches increased an average of 33 percent.
- Peak hour delay at one intersection decreased from 82 seconds per vehicle to 17 seconds per vehicle, translating into a savings of 80,000 vehicle hours per year.

In Austin, Texas, a railroad intersection was converted from an at-grade to a grade-separated crossing. The primary reason behind the construction of the bridge was to improve the safety of the crossing which had experienced a number of deaths resulting from automobile-train collisions. However, a secondary benefit was realized in terms of reduced delay to the traffic stream. It is estimated that 22,000 vehicle hours per year were saved immediately after construction. The estimated savings in vehicle delay based on current traffic counts and train arrival characteristics approached 28,000 vehicle hours per year five years later. The cost of building the grade separation concurrently with the road construction was $2.4 million.

Implementation: Important criteria that should determine when a flyover is warranted include: (Bonilla 1987; Taggart, et al 1987)

- The intersection is congested and capacity problems cannot be resolved using conventional traffic engineering methods.
- The roadway is at least four lanes wide and maximum use of the right-of-way has been made.
- The sum of the critical lane volumes meets or exceeds 1,200 vehicles per hour.
- Obtaining additional right-of-way is not feasible and a minimum right-of-way width of 100 feet (30 meters) is available.
- The accident rate at the candidate intersection is significantly larger than for nearby intersections along the same arterial.
- Adjacent property is not severely impacted.

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References

Bonilla, C. 1987. "Physical Characteristics and Cost-Effectiveness of Arterial Flyovers," Transportation Research Record No. 1122, Transportation Research Board, Washington, D.C.

Taggart, R.C., et. al. 1987. Evaluation Grade-Separated Rail and Highway Crossing Alternatives , NCHRP Report No. 288, Transportation Research Board, Washington, D.C., June.